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October, 1984

Causal Reasoning in Performance Assessment

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This paper was funded, in part, by the Department of Accountancy at the University of Illinois and by a Coopers & Lybrand grant. Comments by Bill Waller, Robin Hogarth, and by participants in an accounting workshop at the University of Arizona are gratefully acknowledged.

ABSTRACT

The role of information in the process of diagnostic inference required for the evaluation of operational performance was investigated. Assuming the role of a manufacturing division manager, subjects were asked to estimate the likelihoods of four potential causes of a department's weekly labor efficiency variance. Given requested items of evidence, subjects were asked to re-estimate the causal likelihoods. The results generally confirmed a set of hypotheses predicting the effects of cause/effect temporal orders and cause/effect covariations, supporting the notions that temporal order and covariation are cues-to-causality used by individuals when inferring causality and that temporal order is a non-compensatory cue. Additional evidence is presented that supports the notion that although individuals prefer evidence concerned with confirming the cause/effect relation to evidence concerned with disconfirming the relation, preference for evidence concerned with disconfirming the relation increases as additional items of evidence are sought.

KEY WORDS:

Managerial Accounting

Performance Assessment

Causal Reasoning

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CAUSAL REASONING IN PERFORMANCE ASSESSMENT

Managers, especially at the middle levels, are faced with determining, or inferring, the nature of the performance of the organization's various subsystems over time. Describing managers' inference processes is important to understanding management control systems (c.f., Shields et al [1981], Birnberg et al [1977]). Einhorn and Hogarth [1981, p. 4] defined practical inference as being "concerned with the validity of predictions and diagnoses, and the utility of actions ... that follow from them." Managers who employ budgeting techniques to help them control the subsystems for which they are responsible must use predictive procedures during the planning of the budget, and must use diagnostic procedures during and after the operation of the subsystems. Consider, for example, a budgeting and cost control system within a manufacturing department. Practical inference involving production planning and standard setting would be concerned with forecasting future events under particular circumstances (e.g., labor productivity given specific wage rates and material quality given specific material prices) and with the validity of those forecasts. Practical inference involving standard cost variance reports would be concerned with the validity of diagnoses (e.g., attributed causes of particular variances) and the net benefits of actions that follow from those diagnoses (e.g., control of the manufacturing process and its costs over time). Given repetitive situations, predictions and diagnoses may be cyclically interconnected. The department's production budget may begin with prediction of production standards and expected achievements, but after a period of time the actual production occurs. When actual production differs from the budget, diagnosis must be made in an effort to understand the cause of such difference. Subsequently, this cycle begins again with prediction of a new production budget.

Diagnostic inference is a central component within an individual's process for understanding his(her) experience with the world. An individual identifies relationships in the events and objects that (s)he experiences as a result of analyzing specific instances of those events and objects [Kuhn, 1970]. An individual's theory of the world is inferred through the repeated diagnosis of experience. The importance of diagnostic inference can be seen in terms of its effect on an individual's prediction of future events and on an individual's choice of action. Prediction depends upon the individual's understanding (inferred theory) of the underlying process that generates outcomes [Einhorn and Hogarth, 1982]. The actions taken by an individual will depend, at least in part, on the individual's beliefs concerning the circumstances that caused (or will cause) the event or situation [Hogarth, 1981]. For example, a manager's understanding of a production variance will depend upon his (her) inferred theory of the processes that generate production variances. Further, different performance evaluations and control actions will result if a production variance is believed to have been caused by a given circumstance (e.g., inadequate production labor efficiency), than if the cause is believed to be a different circumstance (e.g., inadequate production equipment maintenance).

The objective of this paper is to focus on the role of information in the process of diagnostic inference required for the evaluation of operational performance. In other words, how does information affect a manager's diagnosis of the cause(s) of operational performance? Standard labor efficiency variances are employed as accounting reports of operating performance requiring diagnosis <u>prior to</u> formulation of performance evaluations and choice of control actions.[1] Subjects were asked to assume the role of an assistant manager of a manufacturing division, were faced with a

mutually exclusive and exhaustive set of potential causes, and were asked to estimate the likelihoods that the potential causes were actual causes of a reported labor efficiency variance for an assembly department within their division. They were asked to choose four items of evidence (from a provided list) that related to either the occurrence of a potential cause during the period of the reported variance or the frequency of occurrence for a potential cause and a labor efficiency variance over the past five years. The subjects were asked to re-estimate their causal likelihoods after they were given each item of chosen evidence, but were allowed to change the items of evidence they desired to know any time prior to receiving the evidence.

The following section of this paper develops a conceptual framework for the role of causal judgments in diagnostic inference and formulates hypotheses based upon the conceptual framework. A description of the research design, the experiment, results and discussion, and conclusions are contained in the remaining sections.

CONCEPTUAL FRAMEWORK

Diagnostic inference within the context of labor efficiency variances can take the form: a significant, negative labor efficiency variance has occurred in department A, how likely was inadequate worker training to have been the cause? Einhorn and Hogarth [1983a, 1983b] have developed a theory of diagnostic inference in which the answer to this question is affected by three types of information: (1) the assumed causal background (e.g., level of technical knowledge/expertise required of workers, level of capital intensity within the production process, level of managerial expertise and knowledge); (2) the number and strength of specific alternative causes (e.g., inadequate production supervision, poor raw material quality, out-of-date labor efficiency standards); and (3) the judged causal strength of

the potential circumstances being evaluated (e.g., the perceived relationship between the potential cause and the reported variance). Within this study the first type of information will be held constant and the second two types of information will be explored.

Alternative Potential Causes

Einhorn and Hogarth [1983a, 1983b] propose that an individual's assessment of the strength of a potential cause is reduced by the strengths attached to the alternative potential causes. In general, the strength attached to the most likely potential cause in a situation with few causal alternatives would be greater than the strength attached to the most likely cause in a situation with many causal alternatives. Further, the process of diagnostic inference should involve the gathering and evaluating of evidence until the maintained cause is sufficiently likely and the other potential causes are sufficiently unlikely, or until the maintained cause is sufficiently unlikely and must be abandoned in favor of a more likely alternative. As indicated by Einhorn and Hogarth, this concept of inference is consistent with the view of Campbell and Stanley [1963] that the internal validity of a causal hypothesis be evaluated by the ruling out of alternative hypotheses.

In this study the alternative potential causes are presented as being mutually exclusive and exhaustive. In situations such as this, when the strength attached to the most likely potential cause is reduced (i.e., the individual's maintained cause is disconfirmed by evidence), then the strength attached to the most likely alternative cause should increase. Specification of hypotheses concerning the effects of evidence on the likelihood of alternative potential causes will be deferred until the individual's process for judging causal strength is discussed.

Judged Causal Strength

A number of researchers have proposed that individuals use certain cues-to-causality in judging the causal strength of a potential explanation (Einhorn and Hogarth [1983a, 1983b], Kelley and Michela [1980], Mackie [1980]). The cues-to-causality include such factors as temporal order, contiguity, covariation, and similarity of cause and effect. This study will explore individuals' use of two of these cues-to-causality: covariation and temporal order of cause and effect.

Temporal order. Temporal order pertains to the time order of a potential cause and the observed effect. Attribution theory employs the concept of "temporal contiguity" which specifies that events to be considered as cause and effect should occur at essentially the same point in time, and that the "rule of temporal precedence" assumes that the cause must precede the effect (Kelly and Michela [1980]). Einhorn and Hogarth [1983a, 1983b] consider temporal order to be a noncompensatory cue-to-causality: that is, temporal order must be present for the potential cause to have any strength as the perceived cause of the event in question.

When individuals receive evidence about the occurrence of a potential cause relative to a reported event (temporal order evidence), the evidence will either confirm or disconfirm the temporal order of that potential cause and the event. That is, a potential cause occurring during the period of a reported event will confirm that potential cause, and a potential cause not occurring during the period of a reported event will disconfirm that potential cause.

H1a. Those individuals who receive temporal order evidence that confirms the temporal order of their hypothesized cause and the reported event will increase that cause's likelihood between a

first (prior to the evidence) and a second (subsequent to the evidence) evaluation.

H1b. Those individuals who receive temporal order evidence that confirms the temporal order of their hypothesized cause and the reported event will not increase the likelihood of their most likely alternative cause between a first and a second evaluation.

H2a. Those individuals who receive temporal order evidence that disconfirms the temporal order of their hypothesized cause and the reported event will decrease that cause's likelihood between a first (prior to the evidence) and a second (subsequent to the evidence) evaluation.

H2b. Those individuals who receive temporal evidence that disconfirms the temporal order of their hypothesized cause and the reported event will increase the likelihood of their most likely alternative cause between a first and a second evaluation.

Covariation. Attribution theory employs the principle of covariation by which the effect is attributed to that factor with which it is perceived to covary (c.f., Kelly and Michela [1980]). Einhorn and Hogarth [1983a, 1983b] view covariation as a compensatory variable in assessing the causal strength of a factor.

Previous research has found that individuals have difficulties evaluating the extent of covariation present in evidence concerning covariation of potential causes and effects (Crocker [1981]; Nisbett and Ross [1980]). The findings indicate that when the evaluations are data-based, individuals tend to underestimate the objective extent of covariation, and when the evaluations are theory-based, individuals tend to overestimate the objective extent of covariation (c.f., Jennings, Amabile, and Ross [1982]).

Modeling covariation in a 2 x 2 contingency table where both potential cause and effect are considered to be dichotomous variables (either occurring or not occurring), Einhorn and Hogarth view covariation judgments as linear combinations of the subjectively weighted contingency cell frequencies. Einhorn [1980] and Einhorn and Hogarth [1978] discuss difficulties of learning covariation from experience due to not being able to observe all events associated with the contingency table cells (in particular, when a variance does not occur, managers would rarely know if a potential cause did or did not occur).

When individuals receive evidence about the frequencies with which a hypothesized cause and labor efficiency variance have jointly occurred over some relevant past (covariation evidence), the evidence will indicate either positive covariation, negative covariation, or no covariation. When individuals select a specific potential cause as the most likely cause of an event, they form an expectation that the covariation between that cause and the event will be greater than or equal to some minimum level. If subsequent to this evaluation of causal likelihood the individual receives evidence that indicates the covariation is actually below that level, all other things equal the individual should reduce the likelihood of that potential cause. If the subsequent evidence indicates the covariation is actually equal to or above that level, all other things equal the individual should maintain or increase the likelihood of that potential cause.

H3a. Those individuals who receive covariation evidence that confirms a positive covariation between their hypothesized cause and the reported event will either maintain or increase that cause's likelihood between a first (prior to the evidence) and a second (subsequent to the evidence) evaluation.

H3b. Those individuals who receive covariation evidence that confirms a positive covariation between their hypothesized cause and the reported event will not increase the likelihood of their most likely alternative cause between a first and second evaluation.

H4a. Those individuals who receive covariation evidence that does not confirm a positive covariation between their hypothesized cause and the reported event will decrease that cause's likelihood between a first (prior to the evidence) and a second (subsequent to the evidence) evaluation.

H4b. Those individuals who receive covariation evidence that does not confirm a positive covariation between their hypothesized cause and the reported event will increase the likelihood of their most likely alternative cause between a first and a second evaluation.

Empirical evidence indicates some relations between the weights individuals attach to covariation cell frequencies. Nisbett and Ross [1980] review research that indicates individuals may interpret disconfirming evidence differently from confirming evidence, discounting or ignoring the normative effects that disconfirming evidence should have on causal beliefs. Dichotomizing both a potential cause and a reported event into the categories "having occurred" or "not having occurred," evidence concerned with each of the four category combinations can be labeled as being concerned with either confirming or disconfirming the potential cause/effect relation. Other research suggests that although individuals attach more weight to evidence concerned with confirming the cause/effect relation than to evidence concerned with disconfirming the relation, they attach the greatest weight to positive confirming evidence and the least weight to negative confirming evidence (Nisbett and Ross [1980]; Crocker [1981], Crocker [1982]). Evidence that is concerned with both the potential cause

and the event having occurred has been labeled positive confirming evidence. Evidence that is concerned with both the potential cause and the event not having occurred has been labeled negative confirming evidence.

H5b. Those individuals who request covariation evidence will have greatest preference for positive confirming evidence, and will have least preference for negative confirming evidence.

RESEARCH DESIGN

Experimental Environment

The subjects were asked to assume the role of an assistant manager for an electronic communications equipment manufacturing division. Within this role the subjects were presented with a standard cost variance report for an assembly department within their division. Evaluations of the variance report were made with the long-run objective being to assess the quality of control within the assembly department.[2]

The type of standard cost variance reported was a labor efficiency variance labeled as unacceptable. An unacceptable labor efficiency variance was one in which difference between the actual assembly labor hours worked and the standard assembly labor hours allowed for output achieved was greater than 15% of the standard hours allowed. The subjects were told that four potential causes of unacceptable labor efficiency variances were mutually exclusive and exhaustive, and that one, and only one, of the potential causes was the actual cause of a reported variance. The four potential causes included workload schedule, raw material quality, assembly worker training, and department manager's efforts and abilities.

Within this task the information available to the subjects came from three sources.[3] The first source was information from past experience and was presented to the subjects in the form of a background information pamphlet. This pamphlet described the role the subject was being asked to

assume, the company and its manufacturing processes, the accounting control system, and the subject's task and objectives within the experiment.

The second source of information was the variance report and information contemporaneously available with this report. The variance report consisted of the labor efficiency variance and a list of the four potential causes of labor efficiency variances. Information contemporaneously available with this report included the prior probability of an unacceptable labor efficiency variance and the prior probabilities of the four potential causes.

The third source of information was evidence chosen by the subjects from a provided list. The evidence pertained to the four potential causes and was of two general types: temporal order evidence and covariation evidence. Temporal order evidence indicated whether a potential cause was present during the week of the variance (one item of evidence for each of the four potential causes). Covariation evidence indicated the estimated frequency over the past five years of the joint occurrence of a potential cause and a labor efficiency variance (one item of evidence for each of the sixteen possible combinations of four potential causes either occurring or not occurring and of labor efficiency variances being either acceptable or unacceptable).

Experimental Design

The experimental design was a $2^2 \times 4$ repeated measures design with two between-subjects variables, each at two levels, and one within-subjects variable at four levels. The two between-subjects variables were evidence confirmation (either confirming evidence or disconfirming evidence) and the type of evidence selected by the subjects (either temporal order evidence or covariation evidence). The within-subjects variable was the subject's cause rank (ranks one through four). This design was repeated over five

sequential evaluations by each subject (an initial evaluation prior to receiving evidence and an evaluation after receiving each of four items of evidence).

Operationalization of Variables

Cause likelihood was elicited from subjects using 10 point scales. The cause likelihood scale ranged from most unlikely (-10) to equally likely as unlikely (0), and from equally likely as unlikely to most likely (10). The subjects indicated the four items of evidence they most desired to know, in rank order, from a provided list of evidence.

Unacceptable variances had prior probabilities equal to 25%. One potential cause of unacceptable variances (workload schedule) had a prior probability equal to 80%. The other three potential causes (raw material quality, assembly worker training, and department manager's efforts and abilities) had prior probabilities equal to 30%.

Subjects assigned to the confirming condition of the evidence confirmation variable received confirming evidence for the potential cause they considered to be most likely and received disconfirming evidence for all alternative potential causes. Subjects assigned to the disconfirming condition of the evidence confirmation variable received disconfirming evidence for the potential cause they considered to be most likely, confirming evidence for their most likely alternative potential cause, and disconfirming evidence for all other alternative potential causes.

Subjects within the temporal order condition of the type of evidence variable were those subjects who initially selected and received an item of evidence that indicated whether a potential cause had occurred during the week of the reported labor efficiency variance. Subjects within the covariation condition of the type of evidence variable were those subjects

who initially selected and received an item of evidence that indicated the frequency over the past five years with which a potential cause had either occurred or not occurred together with either an acceptable or unacceptable labor efficiency variance.

Confirming covariation evidence indicated that a potential cause and the labor efficiency variance tended to occur together over the last five years (the average correlation was 0.50). Confirming temporal order evidence indicated that a potential cause occurred during the week of the reported variance. Disconfirming covariation evidence indicated that the potential cause had little relation with the labor efficiency variance over the last five years (the average correlation was 0.08). Disconfirming temporal order evidence indicated that a potential cause had not occurred during the week of the reported variance.

THE EXPERIMENT

Subjects

The subjects were undergraduate and master's level graduate students enrolled in a management information systems course in the business school of a large state university. A fixed payment of $5.00 was offered for participating in the experiment, and a total of 40 volunteer subjects participated.[4]

The subjects were randomly assigned to one of the two levels of the evidence confirmation variable (confirming or disconfirming) with the restriction that the two cell sizes remained equal. Upon assignment to a treatment condition each subject received the background information pamphlet.

Procedures

The experiment was conducted in two phases, an experiment phase occurring immediately following a training phase. Both phases were conducted in individual sessions.

The training phase. Training within all treatment conditions consisted of additional written instructions, a period of time in which subjects could ask questions, and a practice labor efficiency variance case. Subjects did not receive evidence or re-evaluate cause likelihoods in the training phase case.

The experiment phase. The experimental phase consisted of obtaining the subjects' responses to a second labor efficiency variance case. Based only upon the background information booklet and the labor efficiency variance report, the subjects were asked to estimate how likely they believed each of the four potential causes were to have been the actual cause of the department's reported labor efficiency variance, and to indicate how confident they were that their estimates of likelihood were accurate. They were then asked to select, in rank order, four items of evidence from the provided list that they would desire to know most in determining the actual cause of the department's labor efficiency variance.

The subjects were given the item of evidence they desired to know most, and were then asked to re-estimate the likelihoods of the potential causes, to re-indicate their confidence, and to re-select the remaining items of evidence (which could either differ or not from their previous selections). This iterative process of evidence selection and re-evaluation continued until the subjects had received four items of evidence. Thus, each subject made five evaluations, one prior to receiving evidence and one after receiving each of four items of evidence.

At the end of the experiment phase the subjects completed a motivation questionnaire and a brief biographical questionnaire. Subjects were debriefed and paid after completing these questionnaires.

RESULTS AND DISCUSSION

Temporal Order and Covariation

The hypotheses concerning temporal order and covariation cues to causality were tested using a $2^2 \times 2$ repeated-measures ANOVA with the change in cause likelihood between the first and second evaluations as the dependent variable. The between-subjects' independent variables were evidence confirmation and evidence type, and the within-subjects' independent variable was the subject's cause rank (first and second). Within this model the hypotheses jointly predict a significant evidence confirmation x evidence type x cause rank interaction. This interaction was significant ($F = 14.9202$; 1 and 36 d.f. and $p < .001$; $\omega^2 = .074$ with the model $R^2 = .738$), is largely in the form predicted, and is graphically presented in Figure 1.

Insert Figure 1 about here

Hypotheses 1a, 1b, 2a, and 2b predicted the effects of the temporal order manipulation on the causal likelihoods the subjects would assign to their most likely potential cause and to their most likely alternative potential cause. The results confirmed all of these hypotheses. Individuals who received confirming temporal order evidence increased the likelihood of their hypothesized cause, but did not significantly change the likelihood of their most likely alternative cause. Individuals who received disconfirming temporal order evidence greatly decreased the likelihood of their hypothesized cause, and increased the likelihood of their most likely alternative cause.

Hypotheses 3a, 3b, 4a, and 4b predicted the effects of the covariation manipulation on the same two causal likelihoods. The results confirmed these hypotheses. Individuals who received confirming covariation evidence did not significantly change the likelihood of either their hypothesized cause or their most likely alternative cause. Individuals who received disconfirming covariation evidence decreased the likelihood of their hypothesized cause, and increased the likelihood of their most likely alternative cause. Hypothesis 3a predicted that the subjects who received confirming covariation evidence would either maintain or increase the likelihood of their hypothesized cause. The results indicated that the likelihood estimates declined, although not significantly different from no change ($t = 0.43$ with 9 d.f.). This result may be due to this study's use of a relatively weak correlation within the confirming condition (average correlation = 0.50). This correlation may have been just below, but not significantly different from, the subjects' pre-evidence expectations of the covariation between their hypothesized cause and labor variances.

Hypothesis 5 predicted the relative weights the subjects would attach to the covariation cell frequencies. These hypotheses were tested using a 2 x 2 contingency table of the frequencies of evidence selection within the covariation condition of the type of evidence variable where the two evidence selection variables were past labor efficiency variances (either unacceptable or acceptable) and past instances of the subject's hypothesized cause (either occurring or not occurring). The obtained contingency table, aggregated over all conditions, is presented in Table 1. This contingency table is significantly different from an expectation of equal cell sizes ($\chi^2 = 119.943$, 1 d.f. and $p < .001$). Out of 87 selections of covariation evidence as the most desired item of evidence, 64 were for positive confirming evidence and only one was for negative confirming

evidence (these two frequency cells contribute 68.4% and 16.5%, respectively, of the X^2 statistic). The remaining 22 selections were for evidence concerned with disconfirming the cause/effect relation. Individuals exhibited greatest preference for positive confirming evidence and least preference for negative confirming evidence. This supports the notions that individuals have difficulty understanding the role of negative confirming evidence and that positive confirming evidence plays a significant role in covariation judgment.

Insert Table 1 about here

The percentages of evidence selections within the covariation evidence condition over the sequential evaluations are presented in Table 2. Although most evidence selections were for evidence concerned with confirming the cause/effect relation, evidence concerned with disconfirming the relation was selected in 25.3% of the instances in which covariation evidence was the most desired item of evidence. When disaggregated into the sequential evaluations, evidence concerned with disconfirming the relation was selected in 42.1% of the instances in which covariation evidence was selected as the final item of evidence. This would support the notion that individuals seek evidence concerned with disconfirming the cause/effect relation, but only after having first sought evidence concerned with confirming the relation.

Insert Table 2 about here

Redundant Evidence

Within 120 evidence selections in which redundant evidence could have been chosen, subjects selected redundant evidence in 15 instances. Redun-

dant evidence was defined as additional items of covariation evidence for causes that subjects had previously received an item of covariation evidence. All 15 instances of redundant evidence selection occurred within the confirming evidence condition, and the mean change in likelihood as a result of the redundant evidence was 1.267 (s^2 = 0.924). In comparison, the mean change in likelihood as a result of non-redundant evidence for subjects in the same confirming evidence condition was 1.097 (s^2 = 1.997). These two means are not significantly different (t = 0.3261 with 49 d.f.). Examining the variances of the likelihood estimates, the pre-redundant evidence variance (4.524) was larger than the post-redundant evidence variance (2.924), although not significantly larger (F_{MAX} = 1.55 with 14 d.f.; critical F_{MAX} at $p < .05$ is 2.86). In comparison, the pre-nonredundant evidence variance (6.504) was little different from the post-nonredundant evidence variance (6.334). These results support the notion that confirming evidence, even when redundant, has an especially large role in causal reasoning.

CONCLUSIONS

Cues to Causality

Two cues to causality were manipulated in this study: temporal order and covariation. Temporal order was tested through conditions in which the subjects received either confirming or disconfirming evidence concerning the occurrence of their hypothesized causes during the period of the reported variance. Supporting the temporal order hypotheses, the subjects' cause likelihood estimates significantly increased when they received confirming temporal order evidence and significantly decreased when they received disconfirming temporal order evidence. Further supporting a temporal order effect is the magnitude of these changes in cause likelihood estimates: the decrease is significantly larger than the increase. A

possible cause not preceding the effect produces a more dramatic change in cause likelihood than occurs when the cause does precede the effect. This supports the view that temporal order is not only a cue-to-causality used by subjects in assessing causal likelihood, but also that it is a non-compensatory cue.

Covariation was tested through conditions in which the subjects received either confirming or disconfirming evidence concerning the frequency of the past occurrence of their hypothesized causes and the variances. Supporting the covariation hypotheses, the subjects' cause likelihood estimates significantly decreased when they received disconfirming covariation evidence. The subjects' cause likelihood estimates also declined, although not significantly different from no change, when they received confirming covariation evidence. This could have been the result of the confirming covariation correlation (0.50) having been just below, but not significantly different from, the subjects' pre-evidence expectation of the covariation. These effects, however, support the notion that covariation is a cue-to-causality used by subjects in assessing causal likelihood.

The subjects preferred evidence concerned with confirming the cause/effect relation to evidence concerned with disconfirming the relation in 65 out of 87 instances, and preferred positive confirming evidence the most (64 instances) and preferred negative confirming evidence the least (one instance). Although this preference for evidence concerned with confirming the cause/effect relation was present in each of the four evidence evaluations, it was declining in favor of an increasing preference for evidence concerned with disconfirming the relation. These results tend to indicate that evidence concerned with disconfirming the relation will be sought by individuals, but only after evidence concerned with confirming the relation is largely exhausted.

Limitations

A major limitation to the generalizability of results would be the use of student subjects within a hypothetical performance evaluation environment. Because these subjects lacked prior training and experience with performance evaluation and control in business contexts, their knowledge of production causal backgrounds could be substantially different from that of actual managers.

The reduction of possible causes of labor efficiency variances to four in number and the assumption that these possible causes were mutually exclusive and exhaustive is an additional limitation to the generalizability of results. Within an actual performance evaluation/control situation the number of possible causes could be larger, may not necessarily be independent of each other, and would not be explicitly stated.

Future Research

Future research should extend this study as well as address the study's limitations. Of particular importance would be the use of natural subjects within experimental environments based upon their natural environments. The assumption of the independence of the possible causes should be relaxed to permit joint causes of events, and more discretionary performance situations should be employed (e.g., research and development departments).

Additional avenues of future research would be the manipulation of information system variables such as the validity of evidence sources, conflicting evidence, as well as the information (evidence) report format, frequency, and level of aggregation. A major impact of managerial accountants within businesses is on the design and operation of managerial information systems and on the training of individuals to utilize these

systems. Knowledge of subjective diagnostic processes is essential to accomplish the objectives of effective system design and adequate individual training.

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FOOTNOTES

[1]Although this study employs a production definition of subsystem operations, this is done for purposes of maximizing the structure of accounting information available within the experimental context. The concepts used in this study should apply equally when an operation is defined to be the accomplishment of any business task.

[2]The quality of control was defined in terms of the department performances being satisfactory to division management. Subjects were instructed that to accomplish such evaluations they should be interested in gaining an understanding of the circumstances that cause good control and good performance as well as the circumstances that cause poor control and poor performance. The subjects were told that this knowledge would allow the division to better train its department managers and to better structure the assembly environment.

[3]Copies of the research instruments may be obtained from the author at the University of Illinois, Department of Accountancy, Champaign, Illinois 61820.

[4]The subjects included 29 males and 11 females. Two subject selection criteria were employed: 1) completion of a managerial accounting or management information systems course, and 2) an overall grade point average of at least 3.5 on a 5.0 scale.

Table 1

Contingency Table of Subjects' Evidence Selections Within the Covariation Condition of the Type of Evidence Variable

Evidence About Past Labor Efficiency Variances	Evidence About Past Instances of the Subjects' Hypothesized Causes	
	Occurring	Not Occurring
Unacceptable	64	20
Acceptable	2	1

Table 2

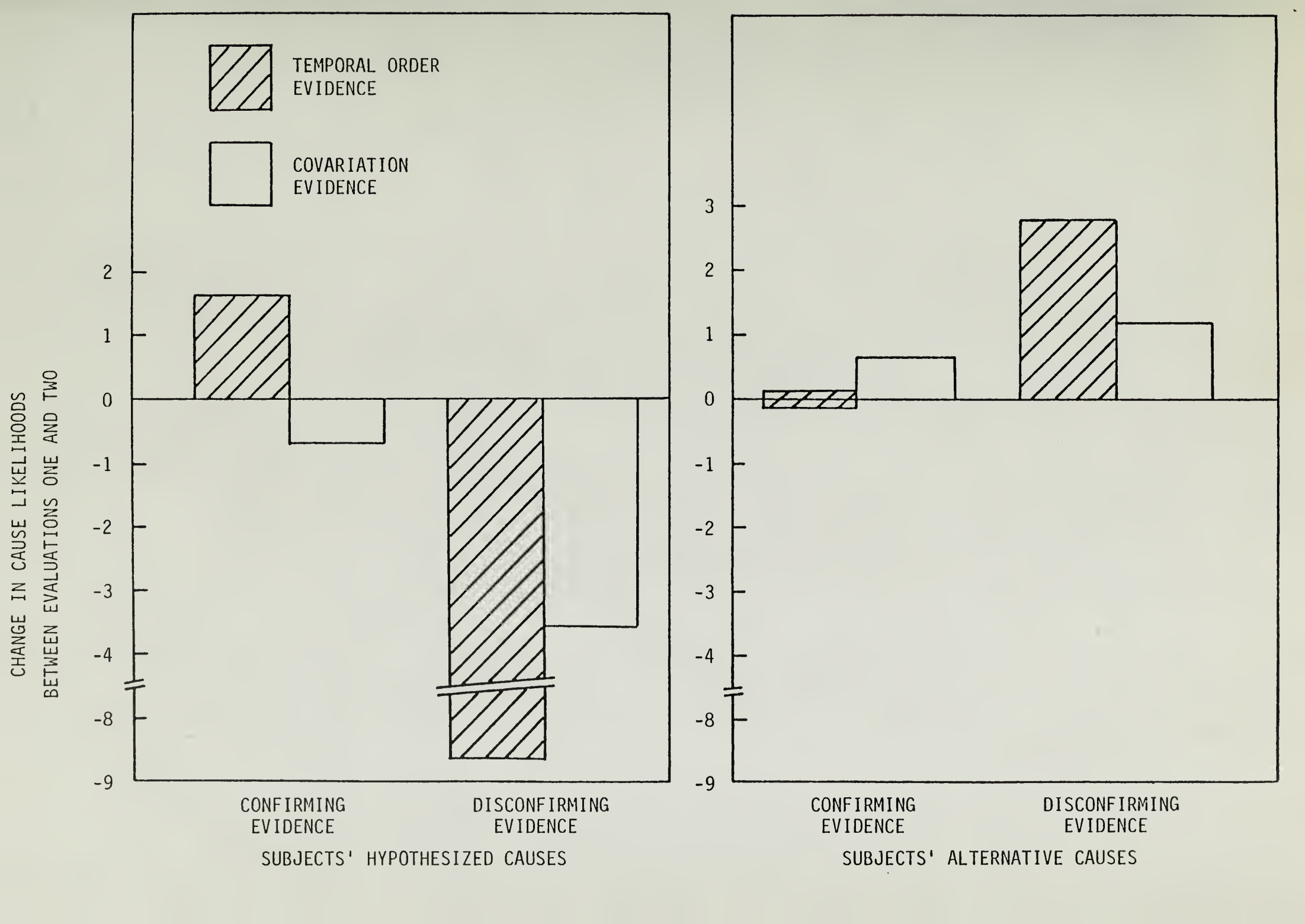
Percentages of Subjects' Evidence Selections Within the Covariation Condition of the Type of Evidence Variable

	Evidence Evaluation			
Evidence Concerned with	1	2	3	4
Confirming Cause/Effect Relation	89.5	80.0	71.4	57.9
Disconfirming Cause/Effect Relation	10.5	20.0	28.6	42.1

Note. Evidence concerned with confirming the cause/effect relation includes both positive confirming and negative confirming evidence.

FIGURE CAPTION

Figure 1. Temporal order and covariation interactions on change in cause likelihood between evaluations one (prior to evidence) and two (after the first item of evidence).


TEMPORAL ORDER EVIDENCE
COVARIATION EVIDENCE
CHANGE IN CAUSE LIKELIHOODS BETWEEN EVALUATIONS ONE AND TWO
3
2
1
0
-1
-2
-3
-4
-8
-9
CONFIRMING EVIDENCE
DISCONFIRMING EVIDENCE
SUBJECTS' HYPOTHESIZED CAUSES
CONFIRMING EVIDENCE
DISCONFIRMING EVIDENCE
SUBJECTS' ALTERNATIVE CAUSES

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